

SPECIFICATIONTITLE OF THE INVENTION  
CHEMICAL LIQUID SUPPLY APPARATUS  
AND  
DEAERATING METHOD THEREOFTECHNICAL FILED OF THE INVENTION

[0001] The present invention relates to a chemical liquid supply apparatus for discharging a predetermined amount of liquids such as chemical liquids and, for example, to a chemical liquid supply apparatus and a deaerating method thereof, which are suitably used for coating a photoresist liquid on a surface of a semiconductor wafer.

BACKGROUND OF THE INVENTION

[0002] In each manufacturing process of various kinds of technical fields such as a semiconductor wafer manufacturing technique, a liquid crystal display manufacturing technique, a magnetic disk manufacturing technique, and a multilayer printed circuit board manufacturing technique, there has been used a chemical liquid such as a photoresist liquid, spin-on glass liquid, polyimide resin liquid, purified water, developer, etchant, cleaning liquid, or organic solvent, and a chemical liquid supply apparatus is used for coating such chemical liquid. For example, as such, a chemical liquid supply apparatus disclosed in U.S. Patent No. 5,061,156 has been already developed.

[0003] For example, in the case of coating the photoresist liquid to the surface of the semiconductor wafer, while the semiconductor wafer is rotated in a horizontal plane, the photoresist liquid is dropped on the surface of the semiconductor wafer from a dispensing

nozzle. In such a chemical liquid supply apparatus, a filter is provided to remove foreign matters contained in the photoresist liquid.

**[0004]** If bubbles are mixed in the apparatus in dispensing the chemical liquid such as a photoresist liquid, the bubbles absorb pressure extruding the chemical liquid and the dispense amount of the chemical liquid becomes unsteady, whereby dispense accuracy thereof is reduced. Therefore, the removal of the bubbles is required to manufacture, with high quality and good yield, integrated circuits formed on the semiconductor wafer.

**[0005]** In the case of a chemical liquid supply apparatus dispensing the chemical liquid by discharge pressure of a pump therein, the bubbles collected in pump volume are ordinarily exhausted to the outside of the chemical liquid supply apparatus, by opening a deaeration valve which is attached to an exhaust flow path connected to a vent port of the filter. In such a manner, the bubbles collected in the filter can be removed to a certain degree.

#### **DISCLOSURE OF THE INVENTION**

**[0006]** However, in such a conventional chemical liquid supply apparatus, it has become clear to be unable to remove completely the bubbles collected in a filtration film of the filter due to matter such as flow resistance of the filtration film, and osmotic pressure of the chemical liquid. As far as the bubbles cannot be exhausted completely from the inside of the filtration film of the filter, it is difficult to dispense stably the chemical

liquid and improve the dispense accuracy. Accordingly, the improved manufacture yield of products is not expected.

**[0007]** An object of the present invention is to stabilize the amount of chemical liquid dispensed from the chemical liquid supply apparatus and to improve remarkably the dispense accuracy.

**[0008]** Another object of the present invention is to manufacture semiconductor integrated circuits with high quality and good yield.

**[0009]** A chemical liquid supply apparatus according to the present invention comprises: a pump discharging a liquid accommodated in a liquid tank; a filter connected to said pump through a pump outlet flow path to which a pump discharge-side valve for opening/closing the flow path is provided; a liquid discharge portion connected to said filter through a liquid discharge flow path to which a discharge valve for opening/closing the flow path is provided; and a vacuum source communicating with said filter through an exhaust flow path to which a deaeration valve for opening/closing the flow path is provided.

**[0010]** The chemical liquid supply apparatus according to the present invention further comprises a control means for closing said pump discharge-side valve and said discharge valve and opening said deaeration valve while said vacuum source is operating. Also, said exhaust flow path is connected to any one of a vent port formed at said filter, or a primary or secondary side of said filter.

**[0011]** Additionally, a deaerating method of a chemical liquid supply apparatus according to the present invention, the apparatus having a pump discharging a liquid accommodated in a liquid tank, a filter connected to said pump through a pump outlet flow path to which a pump discharge-side valve for opening/closing the flow path is provided, and a liquid discharge portion connected to said filter through a liquid discharge flow path to which a discharge valve for opening/closing the flow path is provided, and dispensing the liquid accommodated in said liquid tank from said liquid dispensing portion, comprises a deaerating step of, under such a state that a vacuum source connected to said filter through an exhaust flow path is operating, opening a deaeration valve provided to said exhaust flow path and closing said pump discharge-side valve and said discharge valve to exhaust a gas inside said filter to said exhaust flow path.

**[0012]** Another deaerating method of a chemical liquid supply apparatus according to the present invention, the apparatus having a pump communicating with a liquid accommodated in a liquid tank through a liquid introduction flow path to which a pump inlet-side valve for opening/closing the flow path is provided, the pump discharging the liquid, a filter connected to said pump through a pump outlet flow path to which a pump discharge-side valve for opening/closing the flow path is provided, and a liquid discharge portion connected to said filter through a liquid discharge flow path to which a discharge valve for opening/closing the flow path is provided, and dispensing the liquid in said liquid tank from said liquid dispense portion, comprises the processes of: performing a

sucking operation of said pump under such a state that a deaeration valve provided to an exhaust flow path communicating with an inlet side of said filter, said pump inlet-side valve and said discharge valve are closed, and that said pump discharge-side valve is opened; and performing a discharging operation of said pump under such a state that said deaeration valve and said pump discharge-side valve are opened and that said pump inlet-side valve and said discharge valve are closed.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0013]** FIG. 1 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to an embodiment of the present invention.

**[0014]** FIG. 2A is a process view showing a basic operation in the case where a liquid is dispensed by the chemical liquid supply apparatus, and shows a sucking operation.

**[0015]** FIG. 2B is a process view showing a basic operation in the case where a liquid is dispensed by the chemical liquid supply apparatus, and shows a discharging operation.

**[0016]** FIG. 3 is an explanatory view of a deaerating method of the chemical liquid supply apparatus of the present invention.

**[0017]** FIG. 4 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to another embodiment of the present invention.

[0018] FIG. 5 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention.

[0019] FIG. 6 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention.

[0020] FIG. 7 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention.

[0021] FIG. 8 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention.

[0022] FIG. 9 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention.

[0023] FIG. 10A is an explanatory view of a deaerating method of the chemical liquid supply apparatus as shown in FIG. 9, and shows a sucking operation.

[0024] FIG. 10B is an explanatory view of a deaerating method of the chemical liquid supply apparatus as shown in FIG. 9, and shows an exhausting operation.

#### **BEST MODE FOR CARRYING OUT THE INVENTION**

[0025] Hereinafter, embodiments of the present invention will be detailed based on the drawings.

**[0026]** FIG. 1 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to an embodiment of the present invention. As shown in FIG. 1, the chemical liquid supply apparatus comprises: a pump 11 for discharging a liquid accommodated in a liquid tank 46; a filter 41 connected to the pump 11 through a pump outlet flow path 42 to which a pump discharge-side valve V2 for opening/closing the flow path is provided; a dispensing nozzle (liquid dispense portion) 50 connected to the filter 41 through a liquid discharge flow path 48 to which a discharge valve V4 for opening/closing the flow path is provided; and a vacuum source 8 communicating with the filter 41 through an exhaust flow path 51 to which a deaeration valve V3 for opening/closing the flow path is provided. The structure of the chemical liquid supply apparatus and its components such as the pump 11, the filter 41, etc. basically similar to that disclosed in Japanese Patent Laid-open No. 10-61558 having been devised by the present applicant.

**[0027]** The pump 11 has an expanding/contracting pump chamber 17, a pump inlet 15a, and a pump outlet 16a. In a liquid introduction flow path 45, a pump inlet-side valve V1 for opening/closing this flow path is provided and placed so that one end thereof is connected to the pump inlet 15a of the pump 11 and the other end is put inside the liquid tank 46 accommodating a photoresist liquid.

**[0028]** Therefore, the pump 11 and the liquid tank 46 are connected to each other through the liquid introduction flow path 45.

**[0029]** The pump 11 sucks the liquid accommodated in the liquid tank 46, through the liquid introduction flow path 45 from the pump inlet 15a to an inside of the pump chamber 17 when the pump chamber 17 is expanded, and discharges the liquid from the pump outlet 16a when the pump chamber is contracted.

**[0030]** Since the supplied chemical liquid is the photoresist liquid, the pump 11 is made of a resin material, such as a tetrafluoroethyleneperfluoroalkylvinylether copolymer (PFA) that is a fluororesin, so as not to react with the chemical liquid. However, the resin material is not limited to the PFA, and other resin materials may be used so long as they are elastically deformed.

**[0031]** Further, as a type of the pump 11, a diaphragm type pump may be used so long as it is a displacement type pump.

**[0032]** The filter 41 has: a filter inlet 41a connected to the pump outlet flow path 42; a filter outlet 41b connected to the liquid discharge flow path 48; and a vent port 41c connected to the exhaust flow path 51.

**[0033]** As the filter 41, a filter formed of a hollow fiber film or a sheet-shaped film can be used but not limited thereto so long as it is capable of filtering the chemical liquid.



**[0034]** In the embodiment as shown in FIG. 1, the dispensing nozzle (liquid dispense portion) 50 is provided to a tip of the liquid discharge flow path 48.

**[0035]** As the vacuum source 8, a reciprocal or vane type vacuum pump, an ejector, or the like can be used.

**[0036]** In the liquid discharge flow path 48, a return valve V5 for opening/closing this flow path is provided. Note that as the valves from the pump inlet-side valve V1 to the return valve V5, a solenoid valve operated by electrical signals, an air operated valve, or the like may be used.

**[0037]** In the embodiment as shown in FIG. 1, to control respective operations of the pump 11, the valves from the pump inlet-side valve V1 to the return valve V5, and the vacuum source 8, a system control section 9 is provided, whereby operating signals are sent from the system control section 9 to the pump 11, the valves from the pump inlet-side valve V1 to the return valve V5, and the vacuum source 8.

**[0038]** FIGs. 2A and 2B are process views showing a basic operation in dispensing the chemical liquid by the chemical liquid supply apparatus illustrated in FIG. 1. In these Figures, the reference symbol "OP" shows that the valve is in an open state, and "CL" shows that the valve is in a close state.

**[0039]** To dispense the liquid, first, as shown in FIG. 2A, the pump discharge-side valve V2, the deaeration valve

V3, the discharge valve V4, and the return valve V5 are closed, whereby the pump outlet flow path 42, the exhaust flow path 51, and the liquid discharge flow path 48 each become closed. Further, the pump inlet-side valve V1 is opened, whereby only the liquid introduction flow path 45 becomes opened. Under this condition, a sucking operation of the pump 11 is performed. By the sucking operation of the pump 11, the pump chamber 17 is expanded and the photoresist liquid in the liquid tank 46 is sucked into the pump chamber 17.

**[0040]** Next, as shown in FIG. 2B, the pump inlet-side valve V1 is closed, whereby the liquid introduction flow path 45 becomes closed. The pump discharge-side valve V2, the discharge valve V4, and the return valve V5 are opened, whereby the pump outlet flow path 42 and the liquid discharge flow path 48 each become opened. Under this condition, a discharging operation of the pump 11 is performed. By the discharge operation of the pump 11, the pump chamber 17 is contracted, so that the photoresist liquid in the pump chamber 17 is discharged from the dispensing nozzle (liquid dispense portion) 50 and is dispensed to a surface of a semiconductor wafer W.

**[0041]** Thus, with the sucking and discharging operations of the pump 11, the valves from the pump inlet-side valve V1 to the return valve V5 are opened/closed, whereby the respective flow paths are opened/closed. Therefore, the chemical liquid supply apparatus can perform a chemical liquid discharge/supply operation for dispensing the chemical liquid.

**[0042]** After the chemical liquid is dispensed, the discharge valve V4 is closed and simultaneously the operation of the pump 11 is stopped, and a suck-back operation (not shown) is performed. The suck-back operation is performed by operating the return valve V5. Due to this, the photoresist liquid enters into the dispensing nozzle (liquid dispense portion) 50, so that the liquid is prevented from dripping.

**[0043]** FIG. 3 is an explanatory view of a deaerating method of the chemical liquid supply apparatus according to the present invention. First, the pump discharge-side valve V2, the discharge valve V4, and the return valve V5 are closed, whereby the pump outlet flow path 42 and the liquid discharge flow path 48 each become closed. The deaeration valve V3 is opened, whereby the liquid introduction flow path 45 becomes closed. Under this condition, the vacuum source 8 is operated. By doing so, the bubbles collected inside the filtration film of the filter 41 can be removed completely. Therefore, it is possible to dispense stably the chemical liquid and improve remarkably the dispense accuracy, and consequently to manufacture semiconductor integrated circuits with high quality and good yield.

**[0044]** Hereinafter, a chemical liquid supply apparatus other than that of the embodiment as shown in FIG. 1 will be illustrated. In Figures described later, the same components as those shown in FIG. 1 are denoted by the same reference symbols.

**[0045]** FIG. 4 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to another embodiment of the present invention. The chemical liquid supply apparatus shown in FIG. 4 is characterized in that a buffer tank 57 is placed between the filter 41 and the vacuum source 8.

**[0046]** As shown in FIG. 4, the buffer tank 57 is such that the inside thereof accumulates the photoresist liquid and the bottom is provided with a liquid exhaust flow path 55. The exhaust flow path 51 extending from the vent port 41c of the filter 41 is placed so that a tip thereof is put below a liquid level of the photoresist liquid in the buffer tank 57. An exhaust flow path 54 is placed so that one end thereof is put above the liquid level of the photoresist liquid in the buffer tank 57 and the other end is connected to the vacuum source 8.

**[0047]** Accordingly, the filter 41 and the buffer tank 57 are connected to each other through the exhaust flow path 51, and the buffer tank 57 and the vacuum source 8 are connected to each other through the exhaust flow path 54. By operating the vacuum source 8, if the inside of the buffer tank 57 is filled with the photoresist liquid, a discharge valve V6 is opened to discharge the photoresist liquid.

**[0048]** The case of the embodiment shown in FIG. 4 also has basically the same structure as that shown in FIG. 1 in that the bubbles in the filter 41 can be removed from the exhaust flow path 51 connected to the vent port 41c, thereby having the same operations and effects.

[0049] FIG. 5 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention. The embodiment shown in FIG. 5 is characterized in that the vacuum source 8 is provided to a downstream side, that is, a secondary side of the filter 41. An exhaust flow path 58 is such that one end thereof is connected to a portion between the filter outlet 41b and the discharge valve V4 of the liquid discharge flow path 48 and that the other end is connected to the vacuum source 8. That is, the vacuum source 8 and the filter 41 communicate with each other through an exhaust flow path 58 to which a deaeration valve V7 for opening/closing the flow path is provided.

[0050] Also in the case of this embodiment, similarly to the embodiment shown in FIG. 1, in accordance with the sucking and discharging operations of the pump 11, the valves from the pump inlet-side valve V1 to the return valve V5 and the deaeration valve V7 are opened/closed, whereby the respective flow paths are opened/closed, and therefore, the chemical liquid supply apparatus can perform the chemical liquid discharge/supply operation for dispensing the chemical liquid.

[0051] Additionally, the valves from the pump inlet-side valve V1 to the return valve V5 are closed, whereby the pump outlet flow path 42, the liquid discharge flow path 48, and the exhaust flow path 51 each become closed. The deaeration valve V7 is opened, whereby the exhaust flow path 58 becomes opened. Under this condition, the vacuum source 8 is operated. Therefore, since the embodiment

shown in FIG. 5 can remove completely the bubbles collected inside the filter 41, it has the same operations and effects as those of the chemical liquid supply apparatus shown in FIG. 1.

**[0052]** FIG. 6 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention. The case of the embodiment shown in FIG. 6 is the same as the embodiment shown in FIG. 5 in that the vacuum source 8 is provided to a downstream side, that is, a secondary side of the filter 41, and is the same as the embodiment shown in FIG. 4 in that the buffer tank 57 is provided to a primary side of the vacuum source 8. Accordingly, the embodiment shown in FIG. 6 also has the same operations and effects as those of the chemical liquid supply apparatus shown in FIG. 1.

**[0053]** FIG. 7 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention. The embodiment shown in FIG. 7 is characterized in that the vacuum source 8 is provided to an upstream side, that is, a primary side of the filter 41. An exhaust flow path 59 is such that one end thereof is connected to a portion between the filter inlet 41a and the pump discharge-side valve V2 of the pump outlet flow path 42 and the other end is connected to the vacuum source 8. That is, the vacuum source 8 and the filter 41 communicate with each other through the exhaust flow path 59.

**[0054]** Also in the case of this embodiment, similarly to the embodiment shown in FIG. 1, in accordance with the sucking and discharging operations of the pump 11, the valves from the pump inlet-side valve V1 to the return valve V5 and a deaeration valve V8 are opened/closed, whereby the respective flow paths are opened/closed, and therefore, this chemical liquid supply apparatus can perform the chemical liquid discharge/supply operation for dispensing the chemical liquid.

**[0055]** Additionally, the valves from the pump inlet-side valve V1 to the return valve V5 are closed, whereby the pump outlet flow path 42, the liquid discharge flow path 48, and the exhaust flow path 51 each become closed. The deaeration valve V8 is opened, whereby the exhaust flow path 59 becomes opened. Under this condition, the vacuum source 8 is operated. Therefore, since the embodiment shown in FIG. 7 can completely remove the bubbles collected in the filtration film of the filter 41, it has the same operations and effects as those of the chemical liquid supply apparatus shown in FIG. 1.

**[0056]** FIG. 8 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention. The case of the embodiment shown in FIG. 8 is the same as the embodiment shown in FIG. 7 in that the vacuum source 8 is provided to an upstream side, that is, a primary side of the filter 41, and is the same as each of the embodiments shown in FIGs. 4 and 6 in that the buffer tank 57 is provided to the primary side of vacuum source 8. Therefore, the embodiment shown in FIG. 8 also has the same

operations and effects as those of the chemical liquid supply apparatus shown in FIG. 1.

**[0057]** FIG. 9 is a liquid circuit diagram showing schematically a chemical liquid supply apparatus according to still another embodiment of the present invention. The case of the embodiment shown in FIG. 9 is characterized in that a system control section 9 controls, without using the vacuum source, the sucking and exhausting operations of the pump 11 and each timing of opening/closing the pump outlet flow path 42, the liquid discharge flow path 48, and the exhaust flow path 51, whereby the bubbles in the filter 41 can be removed.

**[0058]** As shown in FIG. 9, the vent port 41c is provided to a side of the filter inlet 41a of the filter 41, and the exhaust flow path 51 is connected to the filter 41. The respective operations of the pump 11 and the valves from the pump inlet-side valve V1 to the return valve V5 are controlled by signals transmitted from the system control section 9.

**[0059]** FIGs. 10A and 10B are explanatory views of a deaerating method of the chemical liquid supply apparatus shown in FIG. 9. A bubble-removing operation of the chemical liquid supply apparatus shown in FIG. 9 is performed in accordance with the following four processes.

**[0060]** In a first process, the chemical liquid discharging operation is performed. The embodiment shown in FIG. 9 has basically the same structure as that of the embodiment shown in FIG. 1, so that respective operating



procedures of the pump 11 and the valves from the pump inlet-side valve V1 to the return valve V5 are the same as those shown in FIGs. 2A and 2B.

**[0061]** At this time, the chemical liquid supply apparatus is in such a state that the entirety thereof is filled with the chemical liquid. The bubbles collected inside the filter 41 and in each flow path are exhausted from the exhaust flow path 51 by opening the deaeration valve V3 or from the dispensing nozzle (liquid dispense portion) 50.

**[0062]** In a second process, as shown in FIG. 10A, the pump inlet-side valve V1, the deaeration valve V3, and the discharge valve V4 are closed, whereby the liquid introduction flow path 45, the exhaust flow path 51, and the liquid discharge flow path 48 each become closed. Further, the pump discharge-side valve V2 is opened, whereby only the pump outlet flow path 42 becomes opened. Under this condition, the sucking operation of the pump 11 is performed. The sucking operation of the pump 11 causes negative pressure, and the bubbles taken in the filtration film of the filter 41 are isolated from the filtration film and move to the side of the filter inlet 41a inside the filter 41.

**[0063]** In a third process, as shown in FIG. 10B, the pump inlet-side valve V1 and the discharge valve V4 are closed, whereby the liquid introduction flow path 45 and the liquid discharge flow path 48 each become closed. Further, the pump discharge-side valve V2 and the deaeration valve V3 are opened, whereby the pump outlet

flow path 42 and the exhaust flow path 51 each become opened. Under this condition, the discharging operation of the pump 11 is performed. By the discharging operation of the pump 11, the bubbles that exist inside the filter 41 and are moved on the side of the filter inlet 41a are exhausted from the vent port 41c into the exhaust flow path 51. This makes it possible to remove the bubbles collected inside the filtration film of the filter 41.

**[0064]** In a fourth step, the chemical liquid discharging operation is performed as occasion arises, whereby the inside of the supply apparatus is always maintained in such a state that it is filled with the chemical liquid. This is because the bubbles are exhausted along with the chemical liquid.

**[0065]** The above-mentioned second to fourth processes are repeatedly performed until the bubbles in the filtration film of the filter 41 are removed completely.

**[0066]** Thus, the embodiment shown in FIG. 9 can also achieve the objects of the present invention similarly to that shown in FIG. 1.

**[0067]** Needless to say, the present invention is not limited to the above-described embodiments but can be variously modified and altered without departing from the gist thereof.

**[0068]** For example, in the above description, the case where the chemical liquid is used to dispense the photoresist liquid to the semiconductor wafer has been

described. However, the present invention can be applied to supply various kinds of liquids without being limited to the photoresist liquid, and is especially effectively used in the case of filtering and dispensing a liquid in which bubbles easily occur.

[0069] According to the present invention, it is possible to stabilize the amount of the chemical liquid dispensed from the chemical liquid supply apparatus and to improve remarkably the dispense accuracy.

#### **INDUSTRIAL APPLICABILITY**

[0070] As described above, in each manufacturing process of various kinds of technical fields such as a semiconductor wafer manufacturing technique, a liquid crystal display manufacturing technique, a magnetic disk manufacturing technique, and a multilayer printed circuit board manufacturing technique, a chemical liquid supply apparatus and a deaerating method thereof according to the present invention are effectively applied to a chemical liquid needing cleaning characteristics such as a photoresist liquid, spin-on glass liquid, polyimide resin liquid, purified water, developer, etchant, cleaning liquid, or organic solvent.